

CIRCUIT DESCRIPTION

CD-81504-01
ISSUE 4B
APPENDIX 3AC
DWG ISSUE 18AC
DISTN CODE 3M09

12

POWER SYSTEMS
POWER SUPPLY CIRCUIT
DC TO DC TRANSISTOR CONVERTER
±120 VOLT OR ±130 VOLT OUTPUT
-48 VOLT INPUT
610B PLANT

CHANGES

D. Description of Changes

- D.1 Added Circuit Notes 117 and 118.
- D.2 Changes CADs 2, 3 and 5 to agree with Figures 2, 4, A and B. See Circuit Note 118.
- D.3 In Figures 2 and 3, removed leads 1 and 2 to Figure 4 that were associated with leads 1 and 2 to Figures A or B.
- D.4 In Figure 3, added Sheet Note 2 to add information about relay FS.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 52422-RFD-JAL

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CHANGES

B. Changes in Apparatus

<u>B.1</u>	<u>Removed</u>	<u>Replaced By</u>
	Inductor L1, Sheet 1, 241C	Inductor L1, Sheet 1, 1083A

D. Description of Circuit Changes

- D.1 Added circuit note 208.
- D.2 Showed electrical connections for the ZN option to terminals 4B and 3B of the FS relay on sheet 1.
- D.3 Changed the lead designation from 4B to 4 in CAD 3.
- D.4 Added options ZN and ZM to the leads on terminal 9 in CAD 3.
- D.5 Changed the relay designation from FA to FS in CADs 7 and 8.
- D.6 Added a strap between TS(E) terminal 5 and TS(E) terminals in CAD 8.
- D.7 Rating of drawing changed from AT&TCO Standard to Manufacture Discontinued.

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CHANGES

B. Changes in ApparatusB.1 Added

D17, D18, D10 Diodes 458A "ZN" Option
RS Resistor KS-20810,L1A, 2050 ohms "ZN" Option
FS Relay MA6, "ZN" Option
Figs. A and B

B.2 RemovedReplaced ByResistors

R7, KS-14603,L3A, 21.5, Fig. 1	R7, KS-20289,L6C, 21.5, Fig. 1
R8, KS-13492,L2, 470, Fig. 1	R8, KS-20289,L6C, 475, Fig. 1
R9, KS-13492,L2 470, Fig. 1	R9, KS-20289,L6C, 475, Fig. 1
R10, KS-13492,L2, 6800, Fig. 2	R10, KS-20289,L6C, 6810, Fig. 2
R11, KS-13492,L2, 6800, Fig. 2	R11, KS-20289,L6C, 6810, Fig. 2
R12, KS-13492,L2, 6800, Fig. 2	R12, KS-20289,L6C, 6810, Fig. 2
R14, 221A, 383, Fig. 2	R14, KS-20810,L1A, 383, Fig. 2
R15, KS-10266,L3C, 1210, Fig. 2	R15, KS-20289,L6C, 1210, Fig. 2

Resistors (Cont'd)

Removed

R16, KS-13492,L1,
4300, Fig. 3
R17, KS-13492,L1,
12000, Fig. 3
R19, KS-13492,L1,
24000, Fig. 3
R20, KS-13492,L1,
4300, Fig. 3
R21, KS-13492,L1,
12000, Fig. 3
R22, KS-13492,L1,
4300, Fig. 3
R23, KS-13492,L1,
24000, Fig. 3
R25, KS-13491,L1,
30000, Fig. 3
R29, KS-13491,L1,
82000, Fig. 3
R30, KS-13491,L1,
4700, Fig. 3
R35, 221A,
"ZH" option,
42700, Fig. 3

Replaced By

R16, KS-20289,L6C,
4220, Fig. 3
R17, KS-20289,L6C,
12100, Fig. 3
R19, KS-20289,L6C,
23200, Fig. 3
R20, KS-20289,L6C,
4220, Fig. 3
R21, KS-20289,L6C,
12100, Fig. 3
R22, KS-20289,L6C,
4220, Fig. 3
R23, KS-20289,L6C,
23200, Fig. 3
R25, KS-20289,L6C,
28700, Fig. 3
R29, KS-20289,L6C,
82500, Fig. 3
R30, KS-20289,L6C,
4750, Fig. 3
R35, KS-20289,L6C,
"ZH" option,
42700, Fig. 3

Lamps

HNV, 2J, Fig. 3

HNV, K1, Fig. 3

Capacitors

C1, KS-14136,
500, Fig. 1
C3, KS-13810,
"M" option,
125, Fig. 1
C4, KS-13368,L30,
.01, Fig. 1
C5, KS-13810,
"M" option,
125, Fig. 1
C6, KS-14587,
400, Fig. 2

C1, KS-19846,L6,
500, Fig. 1
C3, KS-19827,L5,
"M" option,
125, Fig. 1
C4, KS-16742,L34,
.01, Fig. 1
C5, KS-19827,L5,
"M" option,
125, Fig. 1
C6, KS-19827,L5,
400, Fig. 2

Capacitors (Cont'd)

<u>Removed</u>	<u>Replaced By</u>
C7, KS-14587, 400, Fig. 2	C7, KS-19827,L5, 400, Fig. 2
C8, KS-14587, 400, Fig. 2	C8, KS-19827,L5 400, Fig. 2
C9, KS-14587, 400, Fig. 2	C9, KS-19827,L5 400, Fig. 2
C10, KS-14136, 500, Fig. 2	C10, KS-19846,L6, 500, Fig. 2
C11, KS-14136, 500, Fig. 3	C11, KS-19846,L6 500, Fig. 3
C12, KS-13810, "M" option, 125, Fig. 3	C12, KS-19827,L5, "M" option, 125, Fig. 3
C13, KS-14136, 500, Fig. 3	C13, KS-19846,L6, 500, Fig. 3
C14, KS-13810, "M" option, 125, Fig. 3	C14, KS-19827,L5 "M" option, 125, Fig. 3

Transistors

Q5, 12D, Fig. 2

Q5, 51B, Fig. 2

D. Description of Changes

D.1 Options "ZN" AT&T standard and "ZM" Mfr Disc. added to Figures 1, 2, 3 and 4 to make provisions for connecting to Centralized Status, Alarm and Control System (CSACS) in an unattended office.

D.2 FS MA6 Relay, D19 458A Diode and FS Resistors "ZN" option added to utilize contacts required for CSACS when \pm voltage regulators are furnished.

D.3 D17 and D18 458A diodes "ZN" option added, to provide ground for the -48 volt power required for operation of FS relay.

- D.4 Figures B and A added to show wiring logic circuits of one or two converters connected in parallel for the alarm sending circuit of D.1.
- D.5 Components, as listed in B.2, have been "Removed" and "Replaced By" on a non-option basis to conform with Kearny standarization program.
- D.6 In circuit requirements table information in reference to MA6 Relay added.
- D.7 Information Note 302 added.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 2426-COR

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POWER SYSTEMS
 POWER SUPPLY CIRCUIT
 DC TO DC TRANSISTOR CONVERTER
 ±120 VOLT OR ±130 VOLT OUTPUT
 -48 VOLT INPUT
 610B PLANT

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SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 The circuit provides regulated dc voltage for use in coin control applications. The circuit can provide for connections to alarm circuits requiring ground signals and loop closure. Provision for reliability is made by having duplicate load-sharing converters paralleled across the load. Failure of one converter will automatically cause the stand-by converter to assume the whole load.

2. GENERAL DESCRIPTION OF OPERATION

- 2.01 This circuit consists of a DC to DC converter, filter and alarm circuits, a step voltage regulator, output voltage regulators and alarms, distribution fuses and alarm circuit, and polarity alarm relays.
- 2.02 The DC to DC converter employs current feedback to sustain oscillations. A power transistor bridge circuit converts the -48 volt battery input to a square wave. This voltage is stepped up through the main power transformer which has two secondary windings, and is then rectified with two full wave silicon diode bridge circuits.
- 2.03 The filter and alarm circuit consists of two conventional "pi" filters together with a relay and lamp alarm circuit.
- 2.04 The step voltage regulator is designed to hold the output voltage within 100-120 volt limits for load currents from zero to 0.5 amperes and for a seven volt drop in battery input. The circuit consists of a transistor controlled marginal voltage relay which automatically increases the turns ratio of the main power transformer by changing taps when the battery voltage is less than a preselected value. Test and adjustment provisions are included.
- 2.05 The output voltage regulators are designed to maintain the (+) and (-) outputs at limits of 116 to 120 volts or 125 to 135 volts for currents up to 0.75 ampere. This circuit is an emitter follower regulator using zener diodes for reference and two transistors as control elements. No-voltage and high-voltage alarms, test, and adjustment provisions are included. The transistors are protected against short circuits on the output.
- 2.06 The distribution fuses and alarm circuit and the polarity alarm relays provide either conventional ground signals and/or loop-closure signals to externally connected alarm systems.

SECTION II - DETAILED DESCRIPTION1. DC TO DC CONVERTER - FIG. 1

1.01 This circuit employs a bridge of power transistors (Q1-Q4) which periodically reverse battery connections to the primary of step-up transformer T1. A current transformer T2, which has characteristics equivalent to an ideal transformer in parallel with an inductor is connected in series with the two secondaries of T1. Load current is transformed by T2 and applied to the transistor bases in the proper phase to cause oscillations. The outputs of T1 are rectified by silicon power diode bridges (D2-D5) and (D6-D9). The rectified voltages may then be applied to the filter circuits shown in Figure 2 if the step regulated output is desired, or to the regulators shown in Figure 3 if the regulated output is desired. To enable operation at no load, an additional feedback path is provided through resistor R7 which applies low voltage feedback to transformer T2.

1.02 An input filter consisting of inductor L1 and capacitor C1 prevents noise, which may be generated by the converter, from entering the 48-volt battery circuits. Diode D1 protects the transistors during the starting inrush period by clamping the transient voltage rise in the input filter.

1.03 To insure starting, resistors R5 and R6 are connected in such a way as to provide an initial forward bias to transistors Q1 and Q4.

1.04 Base resistors R1 to R4 were added to enable the circuit to operate effectively while using transistors with different parameters. These resistors tend to equalize base drive to the "ON" transistors.

1.05 R-C networks R8-C2 and R9-C4 constitute RF noise filters.

1.06 Transformer T1 is provided with primary taps which enable it to be used with the step regulated or output regulated options. The transformer supplied for the 1130 volt option has no primary taps and is not to be used with the step regulator.

1.07 The converter will not oscillate if any of the bridge transistors are defective.

2. FILTERS, ALARMS, AND STEP VOLTAGE REGULATOR - FIG. 2

2.01 This figure is used only when the step regulated option is employed.

2.02 LC filtering is provided for both the (+) and (-) output voltages, and

consists of inductors L2 and L3 and capacitors C6 through C9. Filter capacitors C3 and C5 are part of the converter section (Figure 1) and are supplied regardless of the option selected.

2.03 A no-voltage alarm circuit is provided, and consists of relay NV, lamp NV, and resistors R10, R11 and R12.

2.04 Major alarms are provided if a single supply is used, while wiring options provide major and minor alarms for duplicate supplies. The failure of either duplicate supply gives a minor alarm. Failure of both gives a major alarm.

2.05 Test jacks are included for connection of an external voltmeter to check each output voltage.

2.06 The step voltage regulator is designed to allow the converter to maintain the output voltage limits as long as the battery voltage does not fall below approximately 47.5 volts. However, if the battery voltage does fall below this value the regulator will act to increase the output voltage by switching taps on the primary of transformer T1.

2.07 When the step regulator is properly adjusted (see Adjustments) and the battery is at approximately 48 volts, transistor Q5 is turned "on" and relay SR is operated. The lead joining the emitter of transistor Q2 and the collector of transistor Q4 is connected to tap 4 on transformer T1. If the battery voltage falls to say, 47 volts, transistor Q5 cuts off, relay SR releases, and the above lead is automatically connected to tap 3 on transformer T1. The output voltage will then rise due to the increased turns ratio of transformer T1. When the battery voltage again rises to its normal level, the circuit will operate to decrease the turns ratio to its normal value.

2.08 Zener diode D22 supplies the reference potential to the emitter of the error detector (transistor Q5). Resistor R13 limits the current through the zener diode. A network consisting of resistors R14 and R15, potentiometers SR ADJ and SR TEST, and zener diode D21 is placed across the battery. Changes in battery potential are sensed by the base of transistor Q5 and converted to changes in collector current. If Q5 is cut off there is no path for relay current and relay SR will release. Capacitor C10 provides a short time delay to prevent the relay from chattering when the input voltage is just at the threshold value.

2.09 The output of each supply is connected through protection diodes D10 and D11 to feed the load. When two

supplies are provided, each supply shares an amount of load depending upon circuit tolerances. If one supply should fail, its diode becomes reverse biased and the other supply handles the total load.

3. OUTPUT VOLTAGE REGULATORS - FIG. 3

3.01 The operation of the (-) regulator only will be described since the (+) regulator functions identically. The base of transistor Q6 is connected to the reference voltage (zener diodes DZ3-DZ4 and varistors DZ5-DZ6 for the -120 volt output, or zener diodes DZ3, DZ4, DZ11, and varistors DZ5, DZ6 for the -130 volt output). The base of Q7 is connected to the reference voltage through the base to emitter junction of Q6. When the circuit is functioning properly the output voltage will be equal to the reference voltage minus the small base to emitter voltage drops of Q6 and Q7. A decrease in output voltage causes an increase in the base to emitter forward bias of transistor Q6 since the base of Q6 is at a constant potential and the emitter is now more positive. The collector current of Q6 increases and in turn causes an increase in the base current of transistor Q7. Q7 is driven further into conduction thus reducing the collector to emitter voltage drop and raising the output voltage. The circuit operates in a similar manner for an increase in output voltage, and thus will regulate for both load and line changes as described above.

3.02 Resistor R18 limits the current through the reference zener diodes.

3.03 Resistor R19 serves to limit transistor leakage current (I_{co}) effects at high temperatures, and enables the circuit to regulate to no load. Leakage current of Q6 can go to ground through R19 instead of being amplified by going through the base of Q7. This also enables the base of Q7 to be reverse biased to minimize its leakage current.

3.04 Capacitor C12 is an added filter and also improves the transient response. In addition, it provides energy storage for blowing the output fuse on a short circuit.

3.05 The series transistors Q6 and Q7 are protected against short circuits on the output. Under normal operating conditions there are about 30 volts across C11 and 5 volts of opposite polarity across D13. D13 is reverse biased and the collector to emitter voltage of Q7 can swing from 0 to 30 volts. If the output is shorted, D13 becomes forward biased and conducts, thus limiting the voltage across Q7 to a value equal to the voltage across C11 (35 volts). Resistors R36 and R38 further protect the transistors by acting as current limiters. Fuse F5 protects the transistors against transients which may occur under short circuit conditions.

An important function of diode D13 is to prevent capacitor C11 from spoiling the transient regulation by keeping it out of the circuit during normal operation.

3.06 Zener diodes DZ13, DZ14 and DZ15; along with the SP relay and resistor R35 shut down the converter when a circuit failure occurs due to overload, short circuit or other conditions which would cause either fuse F5 or fuse F6 to operate. This circuit acts as a voltage monitor. If it detects a low-voltage or no-voltage condition on a converter the SP-relay releases, shorting the output winding of transformer T2 in the converter circuit (Fig. 1) and shutting the converter down.

3.07 Alarm circuits are provided which will operate in the event of circuit failure (no-voltage or low voltage) or high output voltage. The alarm features are similar to those provided for the step regulated option as described in Section 2.05. However, in this case either a high or low failure of either duplicate supply gives a minor alarm. Failure of both gives a major alarm. No provision is made to prevent the output voltage from rising as it will if either supply goes high. It is also assumed that high voltage on one polarity and low voltage on the other polarity of a single supply will not occur simultaneously.

3.08 The no-voltage alarm circuit consists of relay NV, lamp HNV (or NV), and resistors R18 and R24. The NV relay operates when there is no output voltage due to the converter being shut down.

3.09 The HV alarm circuit consists of gas tube V1, resistors R25, R26, R27, R29, potentiometer HV ADJ, capacitor C15, relay HV, lamp HNV (or HV), and switch HV-START (or keys HV ADJ-1 and HV ADJ-2). With resistor R26 temporarily short circuited by turning switch HV-START to the ADJ-1 position (or depressing key HV ADJ-1), potentiometer HV-ADJ is adjusted until tube V1 fires causing relay HV to operate. Resistor R26 is placed back into the circuit by releasing the switch HV-START (or key HV ADJ-1). Switch HV-START is then turned to the START ADJ-2 position (or key HV ADJ-2 is depressed) and released, temporarily opening the circuit to V1. The starting electrodes of V1 are now at a potential higher than the normal firing voltage and will not operate until this voltage is reached. The circuit will operate when the regulator output rises to approximately 130 volts for the ± 120 volt option and 138 volts for the ± 130 volt option. Capacitor C15 is a by-pass which prevents the firing of tube V1 due to voltage transients.

3.10 Test jacks are provided for connection of an external voltmeter to check each output voltage.

4. DISTRIBUTION FUSES AND ALARM CIRCUIT- FIG. 4

4.01 This circuit provides distribution fuses between the regulators, Fig. 2 or Fig. 3 and their loads. Contacts on fuse alarm relays FA and FA1 provide for connections to external alarm circuits requiring either conventional ground signals or loop-closures.

4.02 Operation of a distribution fuse causes relay FA or FA1 to operate, lighting the FA lamp. Grounds are transmitted to alarm circuits requiring ground signals over leads D and DF. Loop closure is transmitted to alarm circuits requiring it over leads D and DD.

5. POLARITY ALARM RELAYS - FIG. 5

5.01 This circuit provided with polarity alarm relays, NA and PA, provides additional alarm leads required in TSPS offices.

6. START OF THE CONVERTER

6.01 Connect power

6.02 Turn HV-START switch to the ADJ-2 position (or depress HV ADJ-2 key) momentarily.

Note: PROLONGED WAITING TO OPERATE THE KEY OR THE ROTARY SWITCH AFTER THE POWER HAS BEEN CONNECTED CAUSES A THERMAL RUNAWAY IN THE BRIDGE TRANSISTORS.

7. ADJUSTMENTS

7.01 To adjust the Step Voltage Regulator:

- (a) Turn SR ADJ potentiometer fully clockwise. Relay SR should release.
- (b) Connect voltmeter (KS-14510 or equivalent) to SR TEST-SR GRD jacks.
- (c) Adjust the SR TEST potentiometer until the voltmeter reads 48.0 volts.
- (d) Slowly turn the SR ADJ potentiometer counterclockwise until the relay operates.
- (e) Readjust SR TEST potentiometer until the relay just releases. The voltmeter should read between 46.9 - 47.7 volts. The relay may be operated and released several times to determine the exact release voltage.
- (f) Turn SR TEST potentiometer fully clockwise. Check relay to see if it is operated.

7.02 To adjust the HV Alarm circuit:

- (a) Turn potentiometer HV ADJ fully counter-clockwise.
- (b) Hold switch HV-START at ADJ-1 position (or hold key HV-ADJ-1 depressed).
- (c) Very slowly turn potentiometer HV ADJ clockwise until relay HV operates and tube V1 fires.
- (d) Release switch HV-START (or key HV ADJ-1).
- (e) Turn switch HV-START to START-ADJ-2 and then release (or depress and then release key HV ADJ-2). Relay HV should release and tube V1 should not fire.

7.03 To insure operation of the HV alarm circuit at the voltage for which it was designed, the following maintenance procedure should be observed at least once a year:

- (a) Turn switch HV-START to ADJ-1 (or depress key HV ADJ-1) momentarily.
- (b) If tube V1 fires and relay HV operates, allow V1 to fire at least one minute before releasing by turning switch HV-START to START ADJ-2 (or with key HV ADJ-2).
- (c) Repeat the adjustment procedure outlined in Section 7.02.
- (d) If tube V1 does not fire (and relay HV does not operate) turn potentiometer HV ADJ until it does.
- (e) Allow V1 to conduct for at least one minute before extinguishing by turning switch HV-START to START ADJ-2 (or depressing key HV ADJ-2).
- (f) Repeat the adjustment procedure outlined in Section 7.02.
- (g) If duplicate supplies are used, repeat the above procedure for the spare supply.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

- 1.01 Input Voltage
 - 45-52 volts DC for ± 120 volt output.
 - 44-52 volts DC for ± 130 volt output.
- 1.02 Output Voltage
 - 100-120 volts DC, 0.50 ampere if converter and step regulators are used.

116-120 volts or, 125-135 volts DC, 0.75 ampere if converter and output voltage regulators are used.

2. FUNCTIONAL DESIGNATIONS

2.01 Relays

<u>Designation</u>	<u>Meaning</u>
FA, FA1	Fuse Alarm
HV	High Voltage
NA	Negative Alarm
NV	No Voltage
PA	Positive Alarm
SP	Short Protection
SR	Step Regulator

2.02 The above meanings also apply to other components or apparatus using the same designations.

3. FUNCTIONS

3.01 To provide a +120 volt and -120 volt or +130 volt and -130 volt power supply for coin control use.

3.02 To provide a means of raising the output voltage for a preselected decrease in battery voltage.

3.03 To provide means of constant output voltage regulation.

3.04 To provide two supplies, paralleled through blocking diodes, which normally share the load.

3.05 To provide high-voltage and no-voltage alarms.

4. CONNECTING CIRCUITS

4.01 Alarm Circuits.

4.02 Power Audible Alarm Circuit - SD-81061-01.

4.03 Audible and Visual Alarm Circuit - SD-96188-01.

4.04 Load Circuits.

5. MANUFACTURING TESTING REQUIREMENTS

5.01 The manufacturing testings requirements are covered in specifications B-132892 and B-136628.

SECTION IV - REASONS FOR REISSUE

A. Changed and Added Functions

A.1 When duplicate converters are provided, a low output voltage on one converter due to a blown F5 and/or F6 fuse in Figure 3 will cause the SP relay to release, shutting down the affected converter and initiating a No Voltage alarm.

Superseded

C2, C4 Capacitors -
KS-13369, L2 (Fig. 1)

DZ1 - Regulating Diode
420N (Fig. 2)

DZ2 - Regulating Diode
420K (Fig. 2)

DZ11, DZ12 - Regulating
Diode 420P (Fig. 3, "S")

R35 Resistor 221A
(Fig 3, "ZH")

Superseded By

C2, C4 Capacitors
KS-13368-L30
(Fig. 1)

DZ1 - Regulating
Diode 446M (Fig. 2)

DZ2 - Regulating
Diode 446N (Fig. 2)

DZ11, DZ12 -Regulat-
ing Diode 446AD
(Fig. 3, "S")

R35 Resistor
KS-13490-L1,
(Fig. 3, "ZJ")
or
R35 Resistor
KS-13490-L1,
(Fig. 3, "ZK")

B.2 Added:

DZ15 - Regulating Diode 446S
(Fig. 3 - "ZJ", "ZK")

D. Description of Changes

D.1 This reissue is to improve the shutdown feature of the converter and also to incorporate changes covered in appendices since the last issue.

D.2 In Figure 1, C2 and C4 capacitors, KS-13369, L2 have been rated "Manufacture Discontinued" and have been replaced by KS-13368, L30.

D.3 In Figure 2, DZ1 regulating diode, 420N, has been rated "A&M only" and has been replaced by the 446M regulating diode.

D.4 In Figure 2, DZ2 regulating diode, 420K, has been rated "A&M only" and has been replaced by the 446N regulating diode.

D.5 In Figure 3, DZ11 and DZ12 regulating diodes, 420P, ("S" option) have been rated "A&M only" and have been replaced by 446AD regulating diodes.

D.6 In Figure 3, diode DZ15 (ZJ, ZK options) is added and resistor R35, 221A ("ZH" option) is superseded by either KS-13490, L1, 7500 ohms ("ZJ" option) or KS-13490, L1, 16000 ohms ("ZK" option). The additional diode (DZ15) with the new resistor values specified, make this branch more sensitive to low output voltages.

D.7 Supplemented circuit note 104 to include reference to "ZH", "ZJ", "ZK" options.

- D.8 Supplemented option index to include ZF and ZG options which were omitted from Issue 14AC. This addition does not affect the manufactured product.
- D.9 Supplemented option index to include ZH, ZJ, ZK options.
- D.10 Added reference to MTR B-136628 for the J86801B converter under Supporting Information.
- D.11 In Figure 3 diodes DZ25 and DZ26 are redesignated as DZ5 and DZ6 to be consistent with WECO T-drawings.
- D.12 Removed option index below circuit note 104. Redundant information - does not affect the manufactured product.
- D.13 Added reference to circuit shutdown feature in circuit note 102.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 2433-DHS

WECO DEPT 8145-WJG-ET